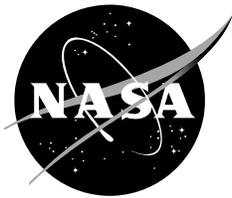


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Automated VAHIRR Product Volume 4 (VAHIRR Factory Acceptance Test)

Joe H. Barrett III
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July 2008

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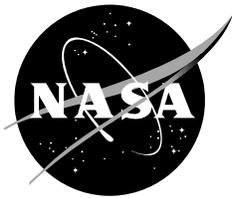
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1. Description of VAHIRR Factory Acceptance Test

The VAHIRR Factory Acceptance Test (FAT) aimed to test the requirements, variable boundaries, and conditional branches appropriate to the source code of the Applied Meteorology Unit (AMU) automated VAHIRR product. In addition, there is a comparison of the automated VAHIRR product with the results of the ABFM II project.

The AMU automated VAHIRR software executes in the Common Operations and Development Environment (CODE) – a single workstation “clone” of an operational Open Radar Product Generator (ORPG). The CODE software provides the current software baseline for the ORPG. Although the environment does not control an Open Radar Data and Acquisition unit (ORDA) nor distribute products to a user, it provides a method for radar data input, uses services identical to an operational ORPG, and creates products identical to those distributed by an operational system. The CODE/ORPG tool set includes sample algorithms, visualization tools and a Human Computer Interface (HCI) to manage the running of the programs. The AMU automated VAHIRR software consists of the VAHIRR executable and modified CODE configuration files to support the VAHIRR product. To test the requirements, variable boundaries and condition branches, data sets were generated using CODE tools. Version 1.1 of the AMU automated VAHIRR software was tested with Build 8-version 2 of the CODE software. More information on the installation of CODE and the VAHIRR product can be found in Volume 3, VAHIRR Installation Guide.

The VAHIRR testing for requirements, variable boundaries, and conditional branches was conducted at the ENSCO Cocoa Beach facility. The comparison of AMU and ABFM VAHIRR results was performed at the AMU in the Morrell Operations Center (MOC) on Cape Canaveral Air Force Station.

2. Pre-Test Procedure

This procedure initialized the system and was performed prior to the start of formal testing.

On the test computer:

- ___ 1) Power on the ORPG-clone.
- ___ 2) Calculate checksums for configuration-management controlled VAHIRR files to be used during testing and verify that the checksums match those recorded in the MD5SUMS file from the delivered installation. Perform checksum calculations and display recorded checksums from the installation directory (`cd $HOME/src/cpc305/tsk007; more MD5SUMS`):
 - `md5sum -b *.c makefile vahirr.h vahirr.mak`
 - `md5sum -b ~/bin/linux_x86/vahirr_prod`
 - `md5sum -b ~/cfg/product_generation_tables`
 - `md5sum -b ~/cfg/extensions/*.sample_snippet`
 - `md5sum -b ~/data/ar2data/BL* ~/data/ar2data/tst6.1*`
- ___ 3) Remotely log onto the ORPG-clone and open four separate terminal windows.
- ___ 4) (Terminal Window #1) Start the Manage RPG task by typing: `mrpg -r -v startup`
- ___ 5) (Terminal Window #2) Invoke the CODEview Graphics GUI by typing: `cvg`
- ___ 6) (Terminal Window #3) Navigate to the \$ORPGDIR/logs directory by typing: `cd $ORPGDIR/logs`
- ___ 7) (Terminal Window #4) Navigate to the cfg directory by typing: `cd cfg`
- ___ 8) (Terminal Window #4) In a text editor, open the file `vahirr_parms.cfg` and verify that the cone of silence height (line 1) is “35” and 0 degrees Celsius (line 2) is “10”.

3. Baseline Test Procedure

The objective of this test procedure was to demonstrate the results of the VAHIRR software for a basic set of inputs. The baseline data set used in the procedure represents various cloud formations within one Volume Coverage Pattern (VCP). A 0° C height of 10 kilofeet (kft) above mean sea level (MSL) and a cone of silence height of 35 kft above ground level (AGL) was used in producing results. Figure 1 depicts the radar baseline data set:

- Between 0.0° and 180.0° azimuth at elevation 4, VAHIRR results were produced from the identified uniform reflectivity values in Figure 1. For elevations 1-3 and 5-9, a reflectivity of -10 dBZ was used.
- Between 180.1° and 225.0 azimuth at elevations 8 and 9, VAHIRR results were produced from a cloud top above the highest scan and a cloud bottom above 0° C. For radar elevations 1-7, a reflectivity of -10 dBZ was used.
- Between 225.1° and 270.0 azimuth at radar elevations 1 - 9, VAHIRR results were produced from a cloud top above the highest scan and a cloud bottom below 0° C.
- Between 270.1° and 315.0 azimuth at radar elevations 1 - 3, VAHIRR results were produced from a cloud top below the highest scan and a cloud bottom below 0° C. For radar elevations 4-9, reflectivity of -10 dBZ was used.
- Between 315.1° and 359.9 azimuth at radar elevation 1, VAHIRR results were produced from a cloud top below 0° C. For radar elevations 2-9, reflectivity of -10 dBZ was used.

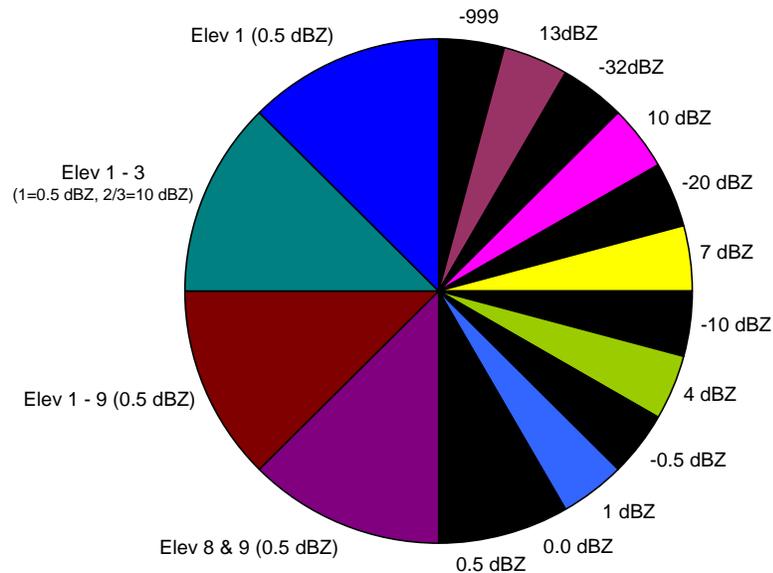


Figure 1. Radar Baseline Data Set.

Baseline Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1, Condition Branches in Section 8 of this volume)

Requirements: 1, 2, 4, 5, 10

Condition Branches: Reflectivity, Altitude of cloud base, Altitude of cloud top

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete.

Date: _____

Start Time: _____

On the test computer

- ___ 1) (Terminal Window #1) Ingest the baseline data file by entering:
`play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1`
Note: This step is complete when the following message is received: “Specified maximum number of volumes reached”.
- ___ 2) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “153” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 3) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 4) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 5) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 against Figure 2. The VAHIRR product shows increasing VAHIRR values with distance from the radar when reflectivity values are held constant. VAHIRR values near the radar (depicted in white) are not calculated due to non-negative reflectivities in the highest elevation scan. VAHIRR values far from the radar (depicted in white) are not calculated since the lowest elevation scan is above the freezing level.
- ___ 6) The VAHIRR product is generated from all of the elevation scans in a volume scan. Figures 3 through 11 show the Base Reflectivity Data Array Product for each elevation scan. To view the product, on the CODEview Graphics GUI, select the **Screen 2** button, select the **PCode** button, enter “94” in the box to the right of **PCode**, and select **Update List & Filter** button.
- ___ 7) On the CODEview Graphics GUI, select the entry for elevation 1 and select **Select Database Product** button.
- ___ 8) In the resulting window, select **OK (Select All)** button. The desired Base Reflectivity Data Array Product is displayed in Graphic Product Display Screen 2.
- ___ 9) Repeat the previous two steps to view the Base Reflectivity products that make up the baseline data set (compare to figures 3 through 11).

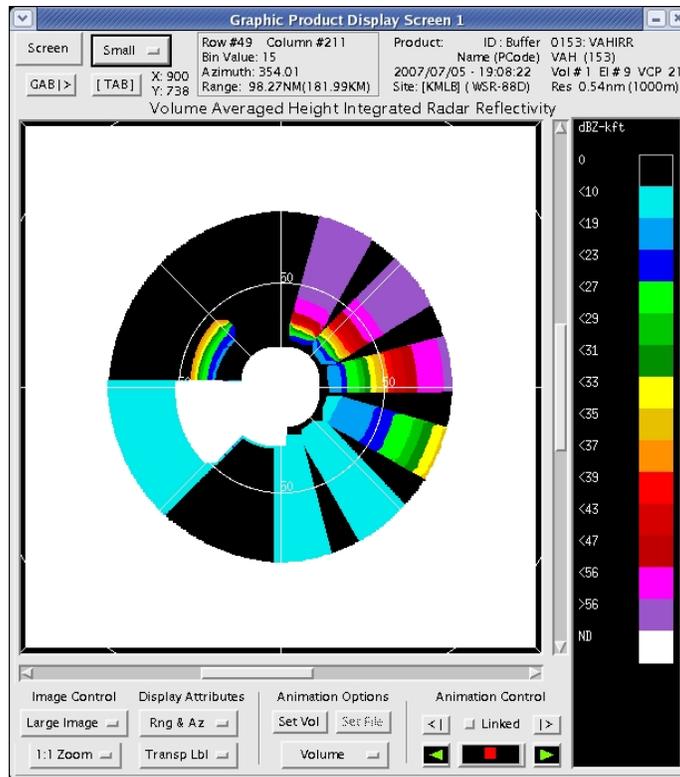


Figure 2. VAHIRR product resulting from the VAHIRR Baseline Test. The color scale for the VAHIRR values is in the right-side of the figure. Areas in which the VAHIRR values are not calculated are displayed in white.

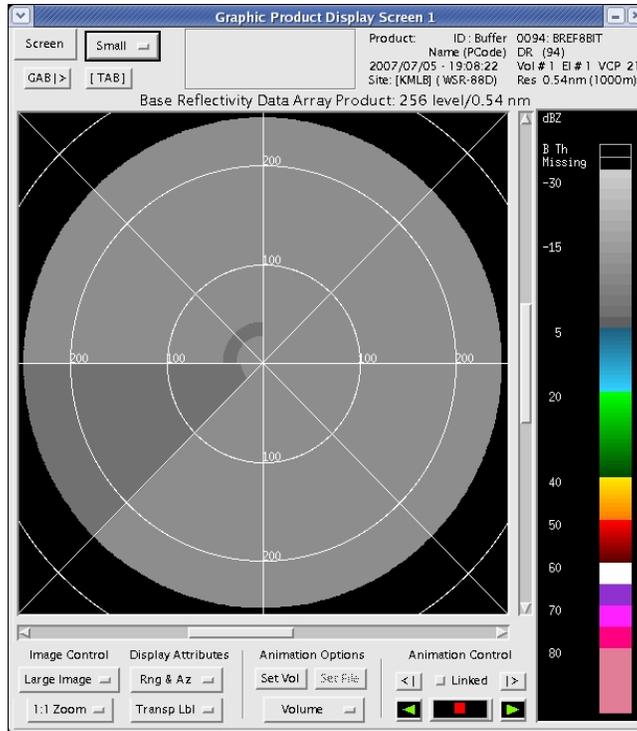


Figure 3. The 8-bit base reflectivity product for Elevation Scan #1 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

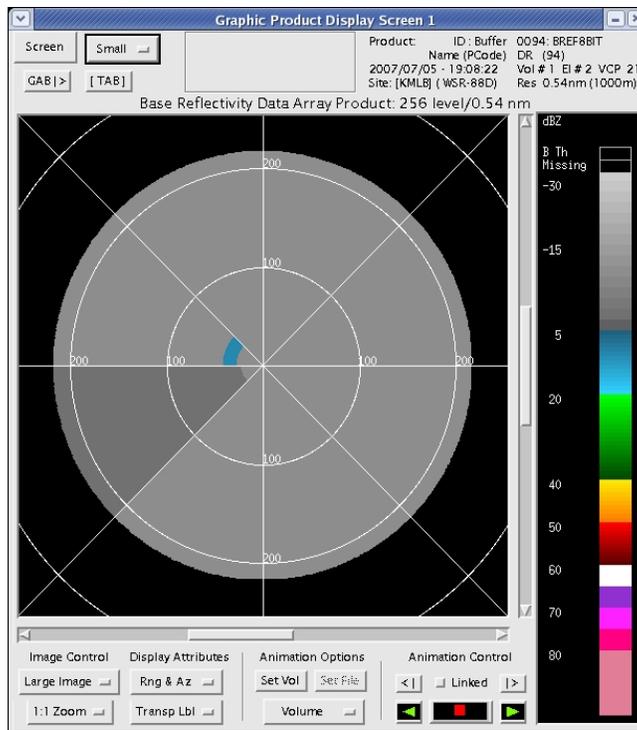


Figure 4. The 8-bit base reflectivity product for Elevation Scan #2 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

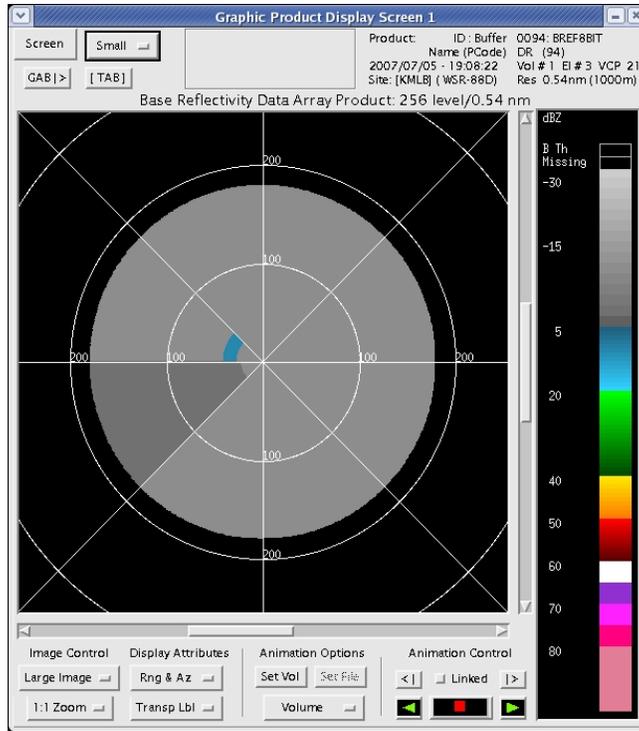


Figure 5. The 8-bit base reflectivity product for Elevation Scan #3 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

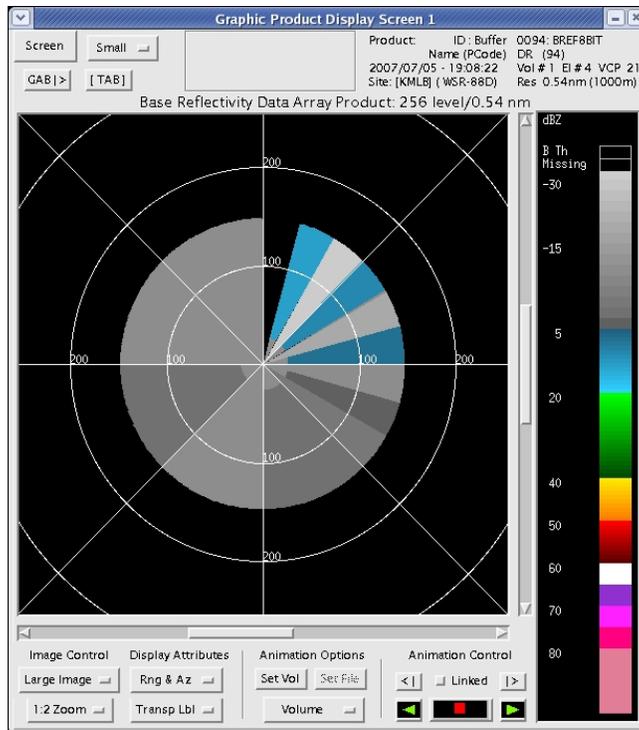


Figure 6. The 8-bit base reflectivity product for Elevation Scan #4 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

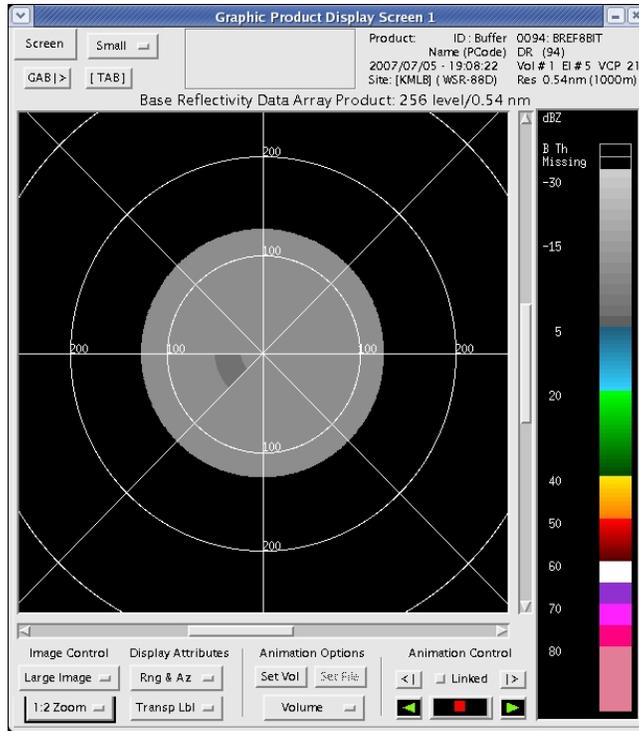


Figure 7. The 8-bit base reflectivity product for Elevation Scan #5 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

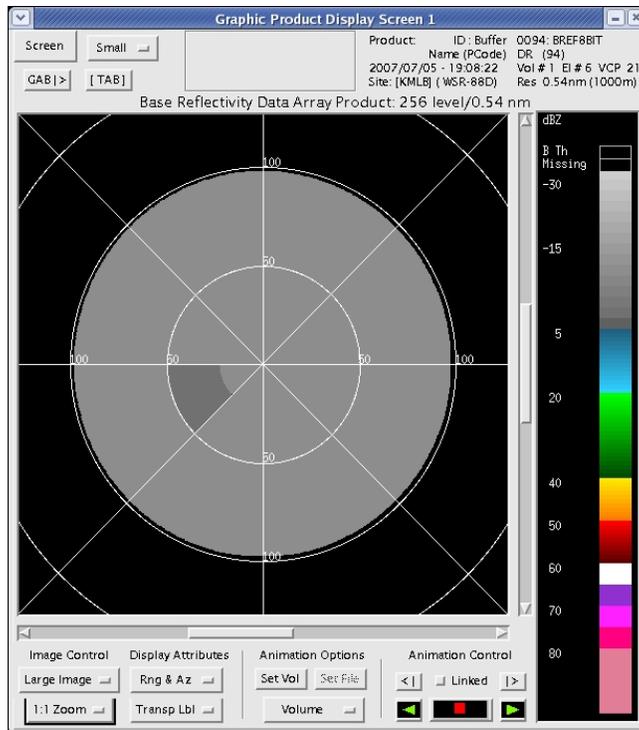


Figure 8. The 8-bit base reflectivity product for Elevation Scan #6 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

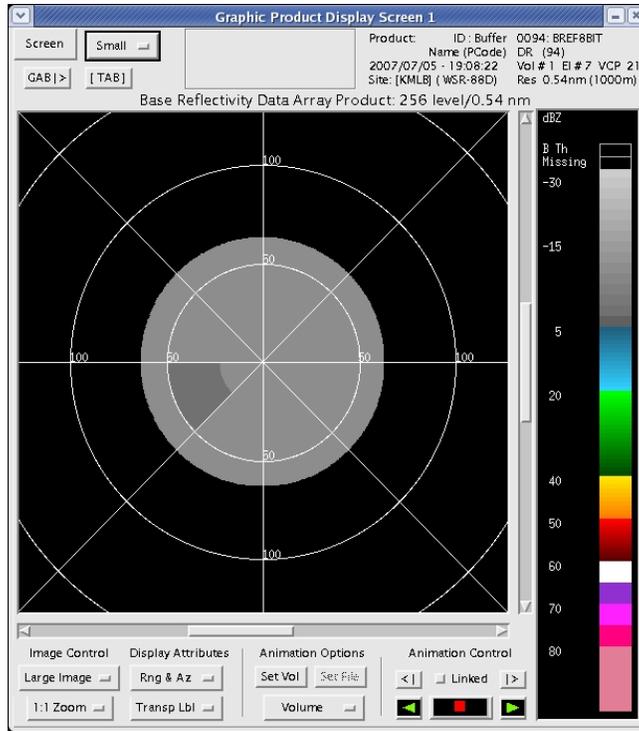


Figure 9. The 8-bit base reflectivity product for Elevation Scan #7 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

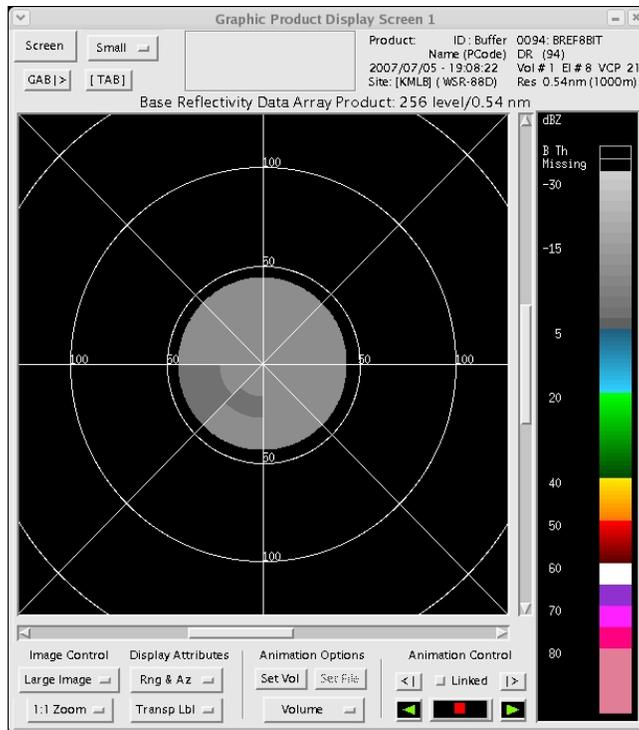


Figure 10. The 8-bit base reflectivity product for Elevation Scan #8 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

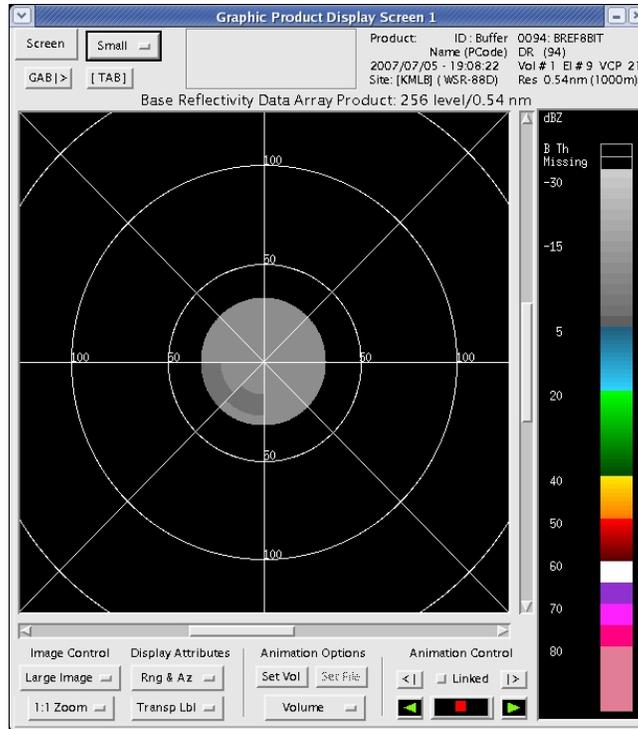


Figure 11. The 8-bit base reflectivity product for Elevation Scan #9 in the baseline data set. The color scale for the reflectivity values is in the right-side of the figure.

4. 0° C Height Test Procedure

The objective of this test procedure was to demonstrate that the AMU software produced the correct results when varying the 0° C height. The baseline data set and a cone of silence height of 35 kft AGL are used in each of the following test cases.

- 0° C Height of -0.1 (boundary testing outside acceptable program range),
- 0° C Height of 0.0 kft MSL,
- 0° C Height of 15 kft MSL,
- 0° C Height of 22.9 kft MSL (~ 7.0 km – highest allowable height), and
- 0° C Height of 23.3 kft MSL (~ 7.1 km - boundary testing outside acceptable program range).

4.1 0° C Height of -0.1 Test Case

VAHIRR Requirements/Condition Branches: None.

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- 1) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the 0° C height (line 2) to be “-0.1”, **Save** and **Close** the file.
- 2) (Terminal Window #1) Ingest the baseline data file by typing:

```
play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>
```

Note: This step is complete when the following message is received: "Specified maximum number of volumes reached".

- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify messages:
0C height parameter - -0.100 kft
ERROR: 0C hght -0.10 kft(msl) = -0.03 km is out of range (0.0 - 7.0 km)
Note: When an error occurs, no VAHIRR result is produced.
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter "153" in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, verify no new VAHIRR result is produced.

4.2 0° C Height of 0.0 kft MSL Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1)

Requirements: 1, 2, 4

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the 0° C height (line 2) to be "0.0", **Save** and **Close** the file.
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:

```
play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>
```

Note: This step is complete when the following message is received: "Specified maximum number of volumes reached".
- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify message:
NOT GOOD: radar height 0.12 kft(msl) is above 0C height 0.00 kft(msl)set 0C height to 0.0 km(agl)
Note: When 0C height is set to 0.0, all grid points become disqualified.
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter "153" in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 to Figure 12. None of the VAHIRR values can be calculated because the lowest elevation scan is above the freezing level.

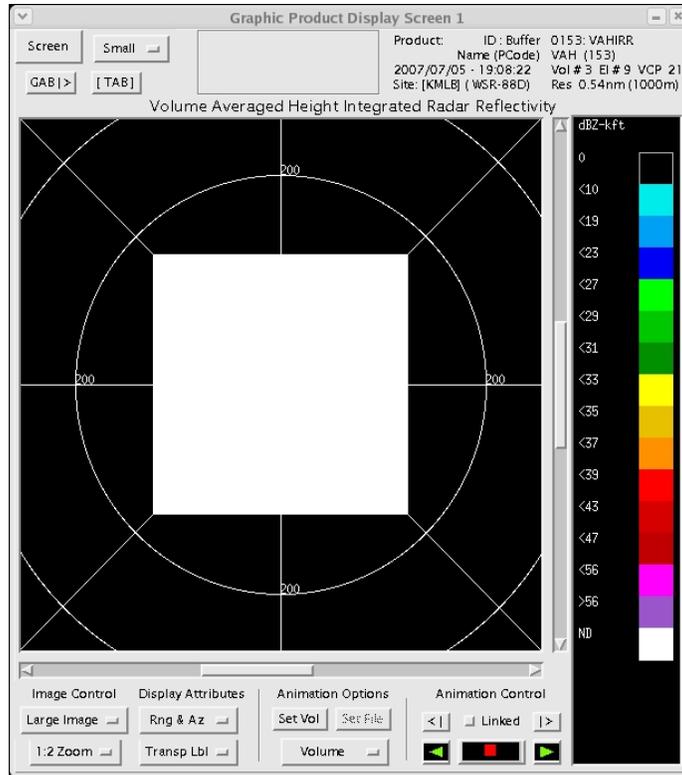


Figure 12. VAHIRR product resulting from the 0° C Height of 0.0 kft MSL Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

4.3 0° C Height of 15 kft MSL Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1, Condition Branches in Section 8 of this volume)

Requirements: 1, 2, 4, 5, 10

Condition Branches: Reflectivity, Altitude of cloud base, Altitude of cloud top

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file **vahirr_parms.cfg** and modify the 0° C height (line 2) to be "**15**", **Save** and **Close** the file.
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:

```
play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>
```

 Note: This step is complete when the following message is received: "Specified maximum number of volumes reached".
- ___ 3) (Terminal Window #3) In an editor, open file **vahirr_prod.output** and verify message:
0C height parameter - 15.000 kft

- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “153” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 to Figure 13. The VAHIRR values beyond 110 n mi from the radar are not calculated, because the lowest elevation scan is above the freezing level.

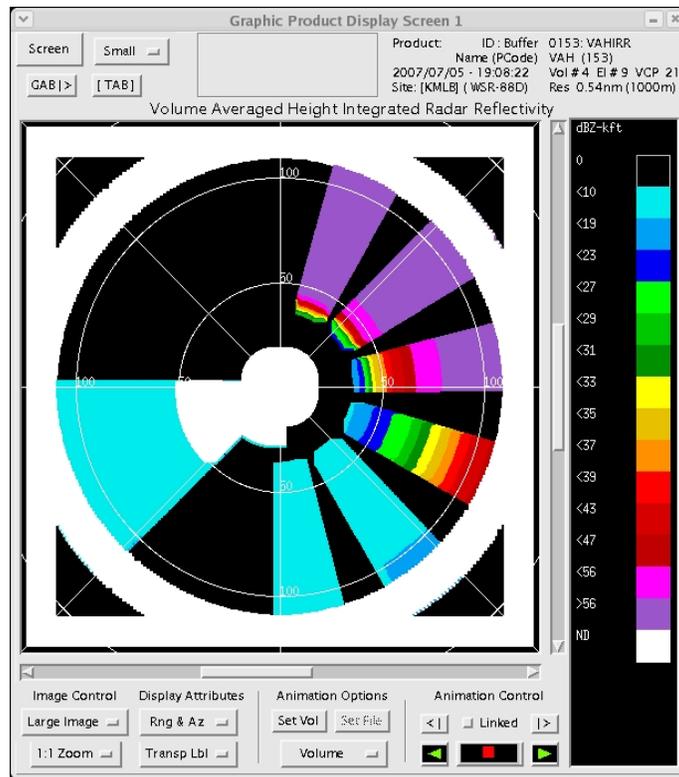


Figure 13. VAHIRR product resulting from the 0° C Height of 15 kft MSL Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

4.4 0° C Height of 22.9 kft MSL (Approx. 7.0 km) Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1, Condition Branches in Section 8 of this volume)

Requirements: 1, 2, 4, 5, 10

Condition Branches: Reflectivity, Altitude of cloud base, Altitude of cloud top

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the 0° C height (line 2) to be “**22.9**”, **Save** and **Close** the file.
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
`play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>`
Note: This step is complete when the following message is received: “Specified maximum number of volumes reached”.
- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify message:
0C height parameter - 22.900 kft
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “**153**” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 to Figure 14. Compared to the previous test case, there is a smaller area in which VAHIRR cannot be calculated. This is because the freezing level is set to a higher altitude.

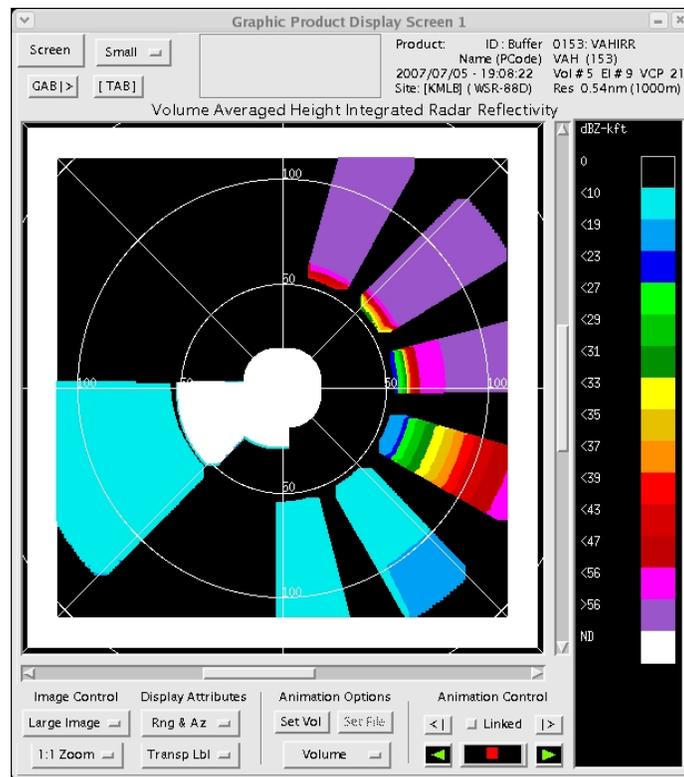


Figure 14. VAHIRR product resulting from the 0° C Height of 22.9 kft MSL Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

4.5 0° C Height of 23.3 kft MSL (Approx. 7.1 km) Test Case

VAHIRR Requirements/Condition Branches: None

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the 0° C height (line 2) to be “**23.3**”, **Save** and **Close** the file.
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
`play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>`
Note: This step is complete when the following message is received: “Specified maximum number of volumes reached”.
- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify messages:
0C height parameter - 23.300 kft
ERROR: 0C hght 23.30 kft(msl) = 7.10 km is out of range (0.0 - 7.0 km)
Note: When an error occurs, no VAHIRR result is produced.
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “**153**” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, verify no new VAHIRR result is produced.

Note: The following steps were not part of formal testing. They were performed to reset the 0°C height.

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the 0° C height (line 2) to be “**10**”, **Save** and **Close** the file.
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
`play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>`
Note: This step is complete when the following message is received: “Specified maximum number of volumes reached”.
- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify message:
0C height parameter – 10.000 kft

5. Cone of Silence Test Procedure

The objective of this test procedure was to demonstrate that the software produced the correct results when varying the cone of silence height. The baseline data set and a 0° C height of 10 kft MSL were used in each of the following test cases:

- Missing Cone of Silence Height (boundary testing outside acceptable program range),
- Cone of Silence Height of -0.1 (boundary testing outside acceptable program range),
- Cone of Silence Height of 0.0 kft AGL (boundary testing the lowest cone of silence height acceptable by the software),
- A Grid Point 5 km From the Cone of Silence (disqualified),
- A Grid Point 6 km From the Cone of Silence (acceptable),

- Cone of Silence Height of 65.616 kft AGL (boundary testing the highest cone of silence height acceptable by the program), and
- Cone of Silence Height of 65.7 kft AGL (boundary testing outside acceptable program range).

5.1 Missing Cone of Silence Height Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1)

Requirements: 1, 2, 4, 5, 10

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) Remove the file, `vahirr_parms.cfg`, from the directory by entering `mv vahirr_parms.cfg vahirr_parms_old.cfg`
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
`play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>`
Note: This step is complete when the following message is received: "Specified maximum number of volumes reached".
- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify message:
Could not open file (/home/codev8/cfg/vahirr_parms.cfg) will use default cone-of-silence 65.616 kft
Note: When the cone of silence height is missing, it is set to the default height of 65.616 kft (20km).
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter "**153**" in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 (zoom Screen 1) to Figures 15 (zoomed in) and 16 (zoomed out). Since the Cone of Silence height is missing, it is set to the default of 20 km. In the figures, the areas within 5 km of the Cone of Silence are displayed in white.

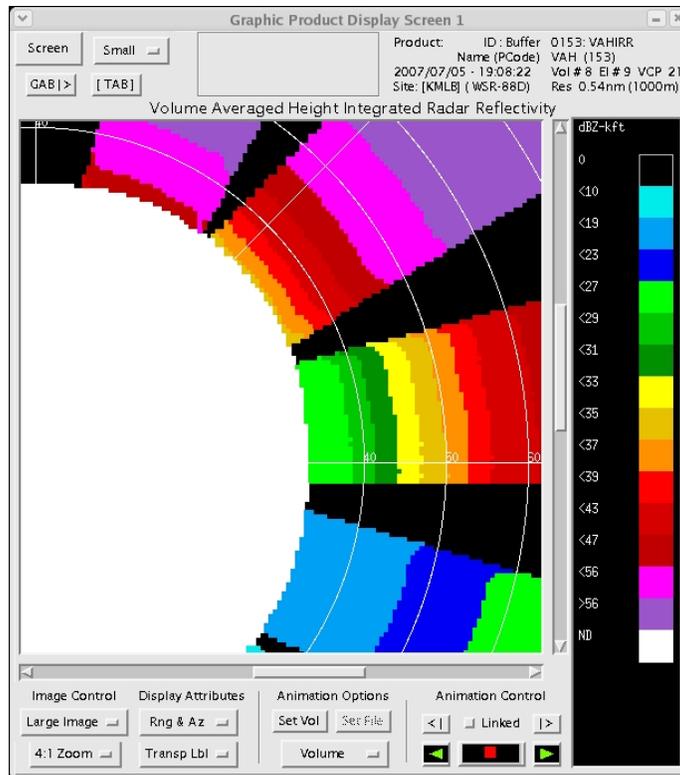


Figure 15. VAHIRR product (zoomed in) resulting from the Missing Cone of Silence Height Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

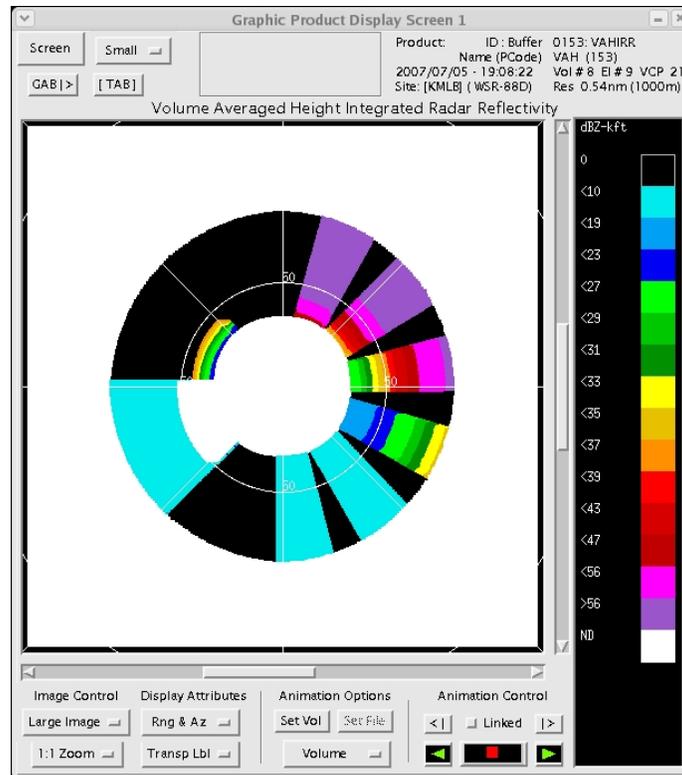


Figure 16. VAHIRR product (zoomed out) resulting from the Missing Cone of Silence Height Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

5.2 Cone of Silence Height of -0.1 Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1)

Requirements: 1, 2, 4, 5, 10

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) Add the file, `vahirr_parms.cfg`, to the directory by typing
`mv vahirr_parms_old.cfg vahirr_parms.cfg`
- ___ 2) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the cone of silence height (line 1) to be “-0.1”, **Save** and **Close** the file
- ___ 3) (Terminal Window #1) Ingest the baseline data file by typing:
`play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>`
Note: This step is complete when the following message is received: “Specified maximum number of volumes reached”.
- ___ 4) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify message:
cone height -0.10 kft/20.00 km (agl)

Note: When the cone of silence height is out of range, it is set to the default height of 65.616 kft (20 km). The message format is “cone height <input>/<program setting>”. If the cone of silence height is out of range, then the second value is always set to 20 km.

- ___ 5) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “**153**” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 6) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 7) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 8) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 to Figure 16. Since the Cone of Silence height is invalid, it is set to the default of 20 km. In the figure, the areas within 5 km of the Cone of Silence are displayed in white.

5.3 Cone of Silence Height of 0.0 kft AGL Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1, Condition Branches in Section 8 of this volume)

Requirements: 1, 2, 4, 5, 10

Condition Branches: Location of box wrt cone of silence

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file **vahirr_parms.cfg** and modify the cone of silence height (line 1) to be “**0.0**”, **Save** and **Close** the file
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>
Note: This step is complete when the following message is received: “Specified maximum number of volumes reached”.
- ___ 3) (Terminal Window #3) In an editor, open file **vahirr_prod.output** and verify message:
cone-of-silence parameter - 0.000 kft
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “**153**” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 to Figure 17. No areas are displayed in white due to the Cone of Silence, since the Cone of Silence height is set to ground level. The white areas to the southwest of the radar are due to non-negative reflectivities in the highest elevation scan.

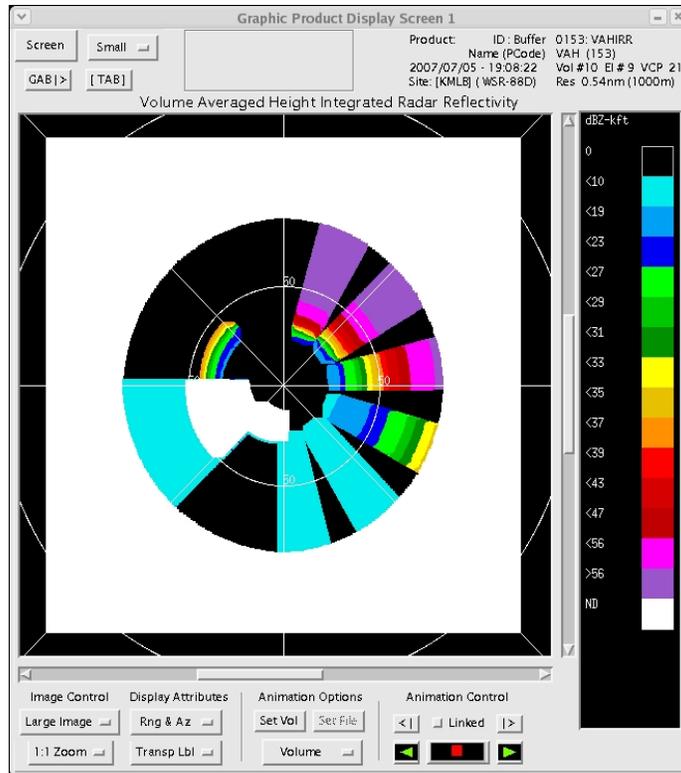


Figure 17. VAHIRR product resulting from the Cone of Silence Height of 0.0 kft AGL Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

5.4 A Grid Point 5 km from the Cone of Silence Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1, Condition Branches in Section 8 of this volume)

Requirements: 1, 2, 4, 5, 10

Condition Branches: Location of box wrt cone of silence

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file **vahirr_parms.cfg** and modify the cone of silence height (line 1) to be "**59.74**", **Save** and **Close** the file
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:

```
play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>
```

 Note: This step is complete when the following message is received: "Specified maximum number of volumes reached".
- ___ 3) (Terminal Window #3) In an editor, open file **vahirr_prod.output** and verify message: **cone-of-silence parameter - 59.740 kft**

- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “**153**” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 (zoom Screen 1) to Figure 18. VAHIRR values (displayed in white) within 5 km of the Cone of Silence are not calculated.
- ___ 8) Compare Figures 18 and 19 (Cone of Silence height set to 59.74 kft) to Figures 20 and 21 (Cone of Silence height set to 35 kft). Since the Cone of Silence height is higher in Figures 18 and 19, the Cone of Silence covers a larger area.

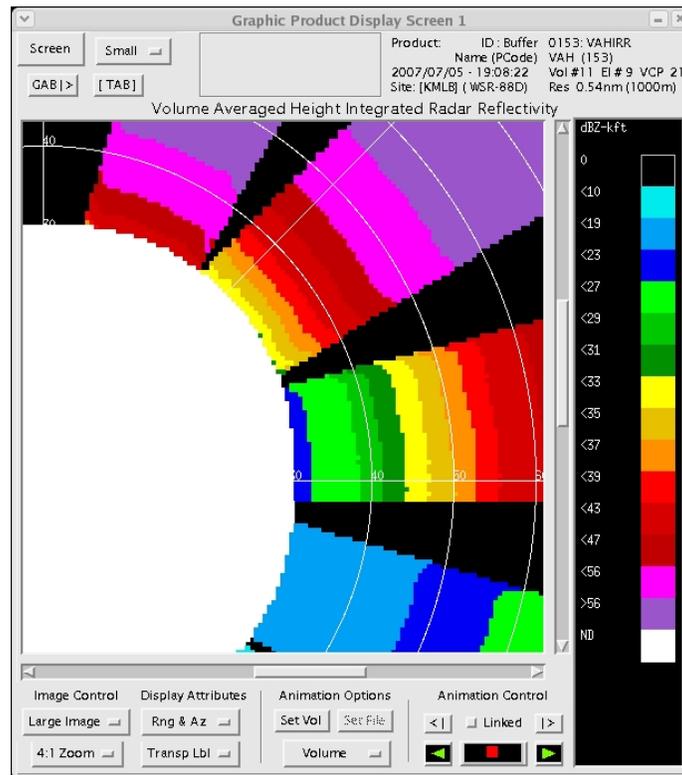


Figure 18. VAHIRR product resulting from the data set used for the Grid Point 5 km from the Cone of Silence Test Case, with Cone of Silence height set to 59.74 kft. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

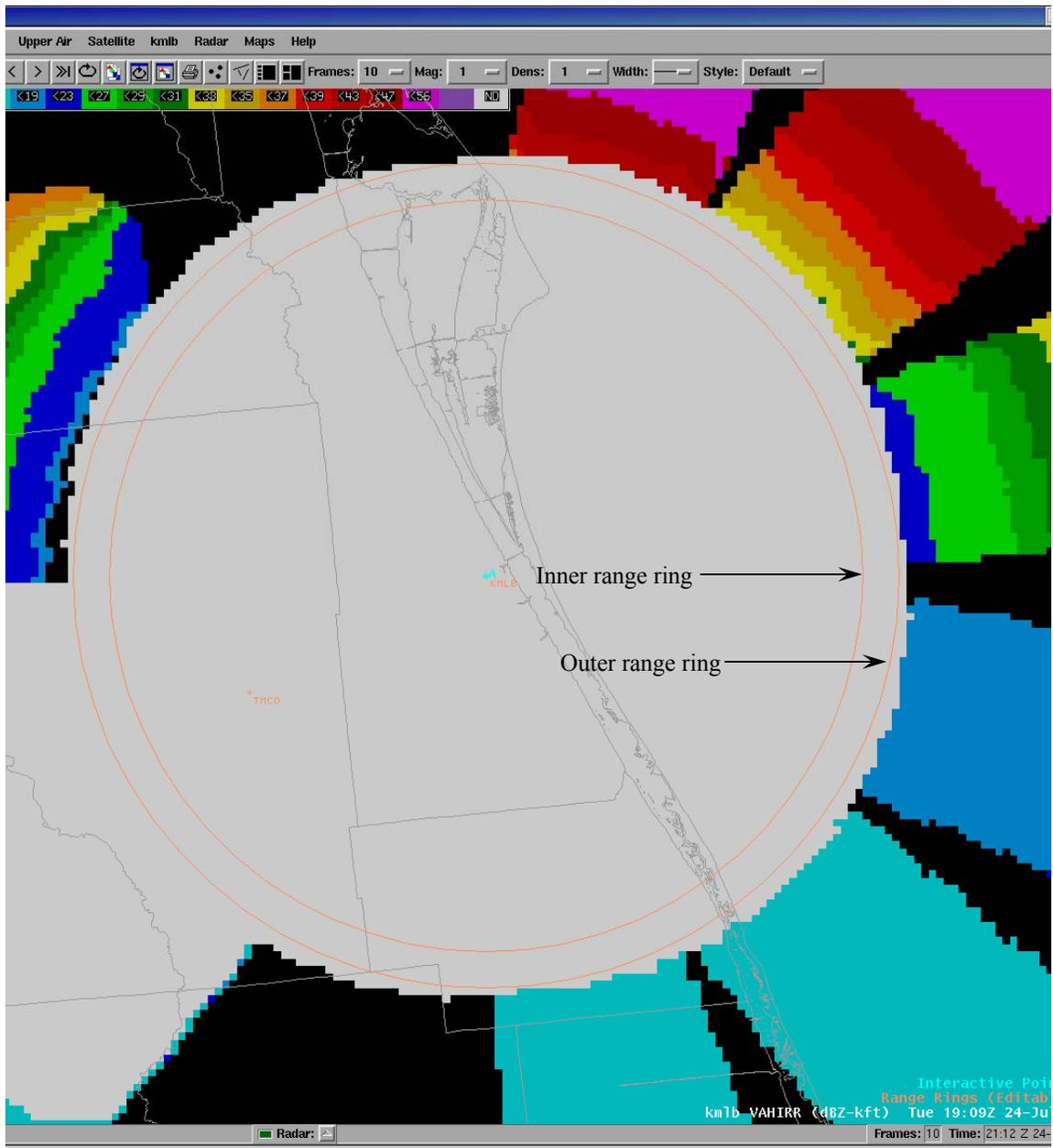


Figure 19. VAHIRR product displayed in AWIPS, resulting from the data set used for the Grid Point 5 km from the Cone of Silence Test Case, with Cone of Silence height set to 59.74 kft. The color scale for the VAHIRR values is in the upper-left portion of the figure. VAHIRR values that cannot be calculated are displayed in light grey. The inner range ring shows the calculated horizontal extent of the Cone Of Silence. The radius of the outer range ring is 5 km larger than that of the inner range ring.

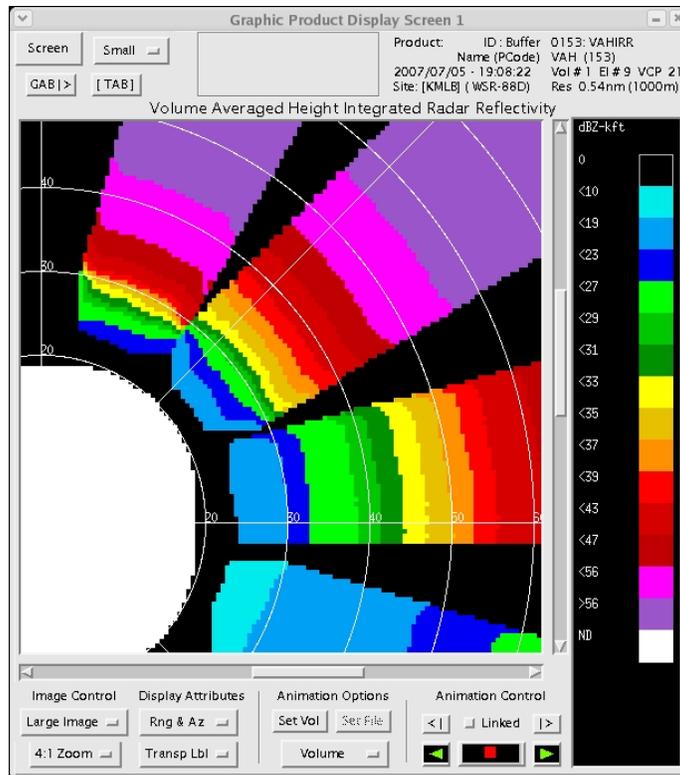


Figure 20. VAHIRR product resulting from the data set used for the Grid Point 5 km from the Cone of Silence Test Case, with Cone of Silence height set to 35 kft. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

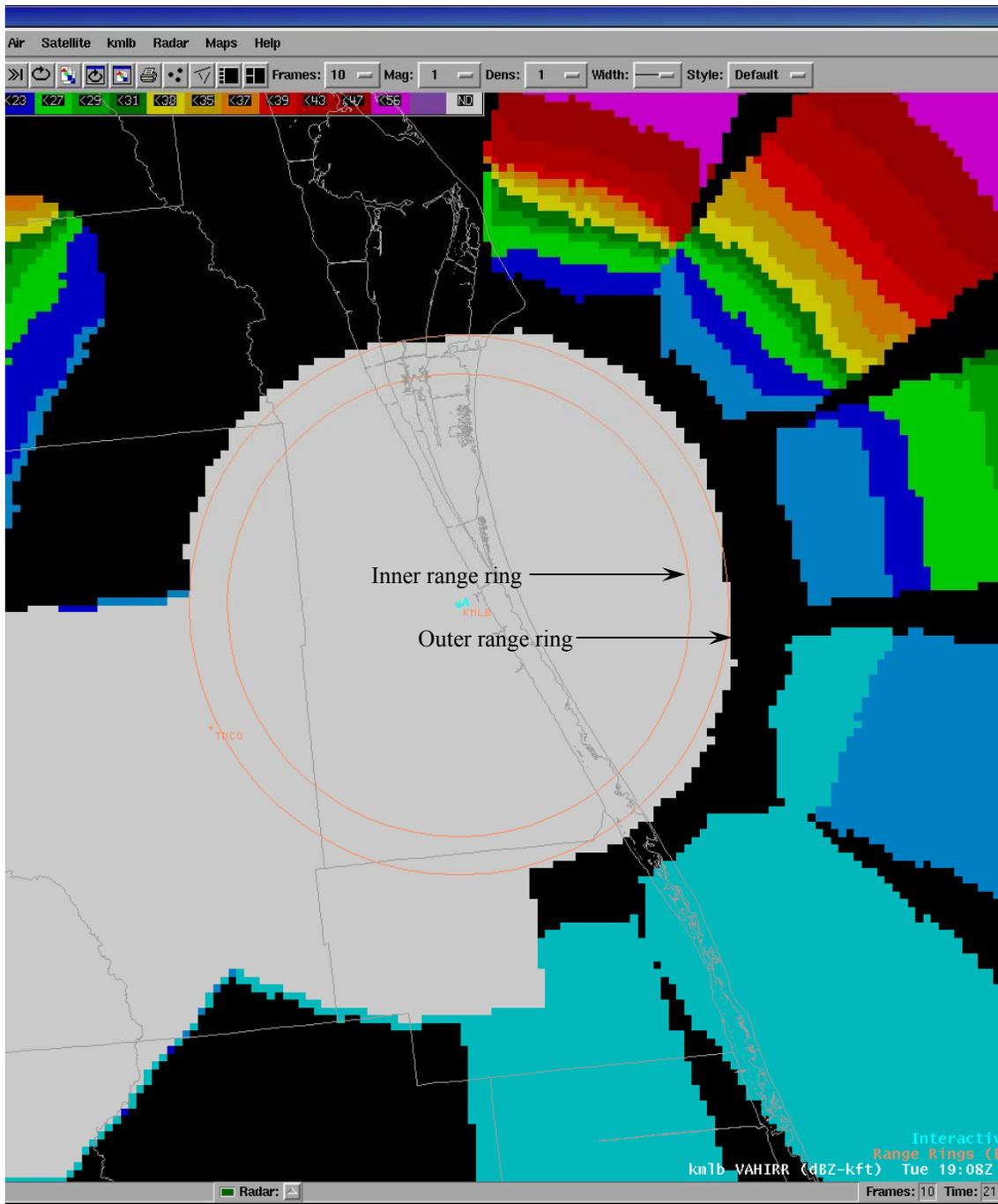


Figure 21. VAHIRR product displayed in AWIPS, resulting from the data set used for the Grid Point 5 km from the Cone of Silence Test Case, with Cone of Silence height set to 35 kft. The color scale for the VAHIRR values is in the upper-left portion of the figure. VAHIRR values that cannot be calculated are displayed in light grey. The inner range ring shows the calculated horizontal extent of the Cone Of Silence. The radius of the outer range ring is 5 km larger than that of the inner range ring.

5.5 A Grid Point 6 km from the Cone of Silence Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1, Condition Branches in Section 8 of this volume)

Requirements: 1, 2, 4, 5, 10

Condition Branches: Location of box wrt cone of silence

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the cone of silence height (line 1) to be "**58.62**", **Save** and **Close** the file.
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
`play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>`
Note: This step is complete when the following message is received: "Specified maximum number of volumes reached".
- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify message:
cone-of-silence parameter - 58.620 kft
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter "**153**" in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 (zoom Screen 1) to Figure 22. VAHIRR values (displayed in white) within 5 km of the Cone of Silence are not calculated.
- ___ 8) Compare Figure 22 to Figures 18 and 20, above. Compare Figure 23 to Figures 19 and 21. The Cone of Silence covers a slightly smaller area in Figure 22 than in Figure 18, since the Cone of Silence height is lower in Figure 22. On the other hand, the Cone of Silence covers a larger area in Figure 22 than in Figure 20, since the Cone of Silence height is lower in Figure 20.

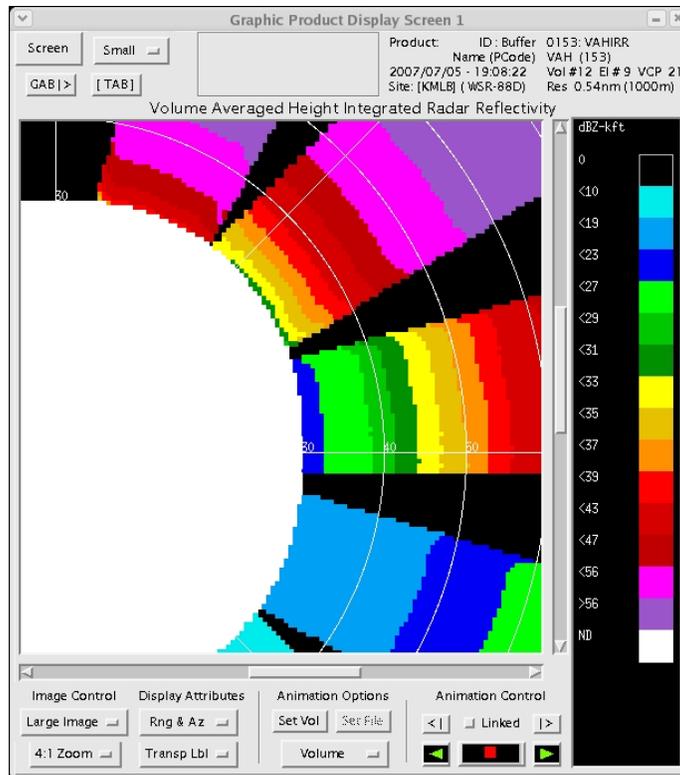


Figure 22. VAHIRR product resulting from the data set used for the Grid Point 6 km from the Cone of Silence Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

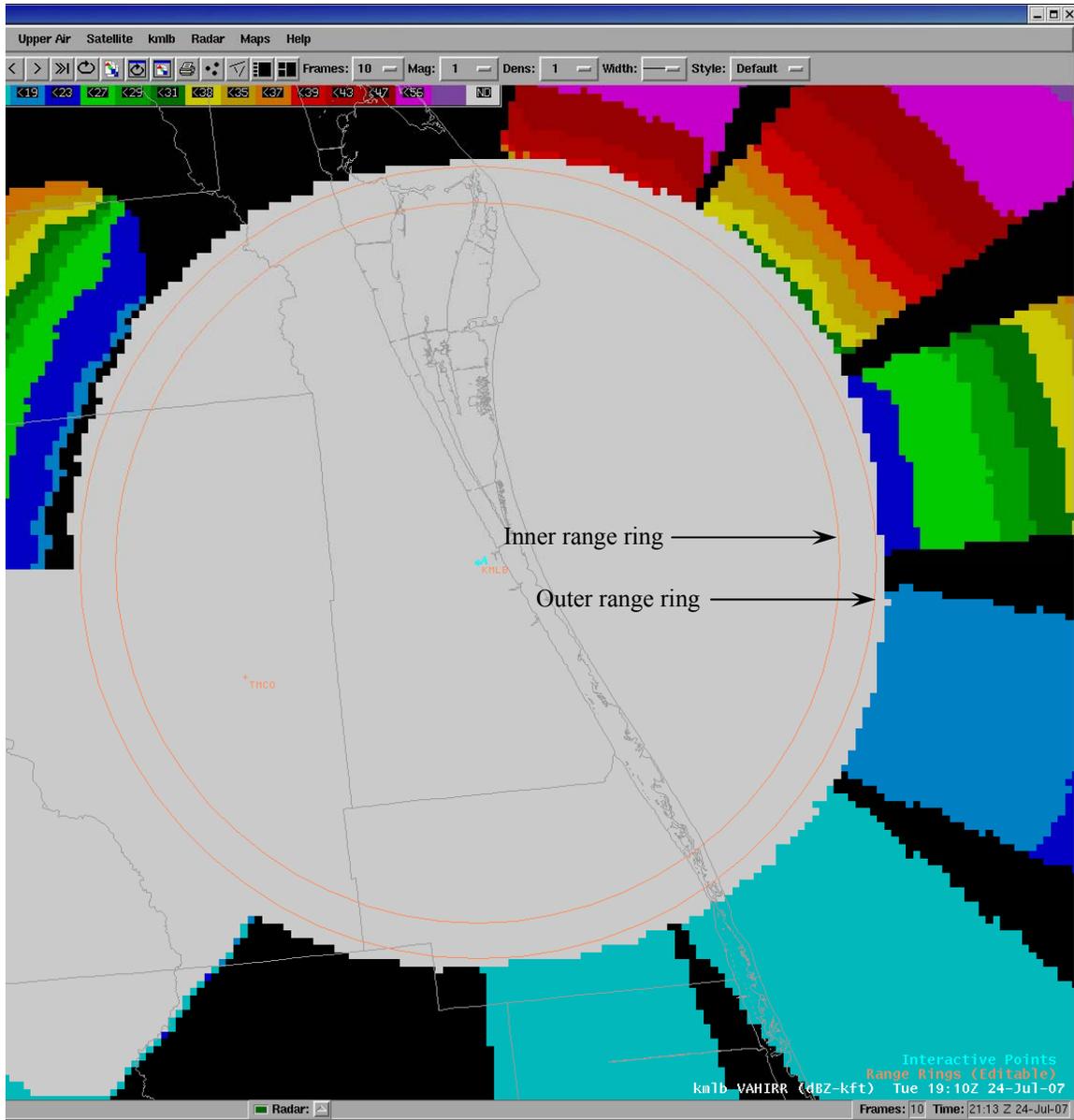


Figure 23. VAHIRR product displayed in AWIPS, resulting from the data set used for the Grid Point 6 km from the Cone of Silence Test Case. The color scale for the VAHIRR values is in the upper-left portion of the figure. VAHIRR values that cannot be calculated are displayed in light grey. The inner range ring shows the calculated horizontal extent of the Cone Of Silence. The radius of the outer range ring is 5 km larger than that of the inner range ring.

5.6 Cone of Silence Height of 65.616 kft AGL Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1, Condition Branches in Section 8 of this volume)

Requirements: 1, 2, 4, 5, 10

Condition Branches: Location of box wrt cone of silence

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file **vahirr_parms.cfg** and modify the cone of silence height (line 1) to be "**65.616**", **Save** and **Close** the file
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>
Note: This step is complete when the following message is received: "Specified maximum number of volumes reached".
- ___ 3) (Terminal Window #3) In an editor, open file **vahirr_prod.output** and verify message:
cone-of-silence parameter – 65.616 kft
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter "**153**" in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 to Figures 24 and 25. The Cone of Silence height has been set to the maximum height of 20 km. In the figures, the areas within 5 km of the Cone of Silence are displayed in white. Figure 26 is the same as Figures 24 and 25, except it is displayed in AWIPS.

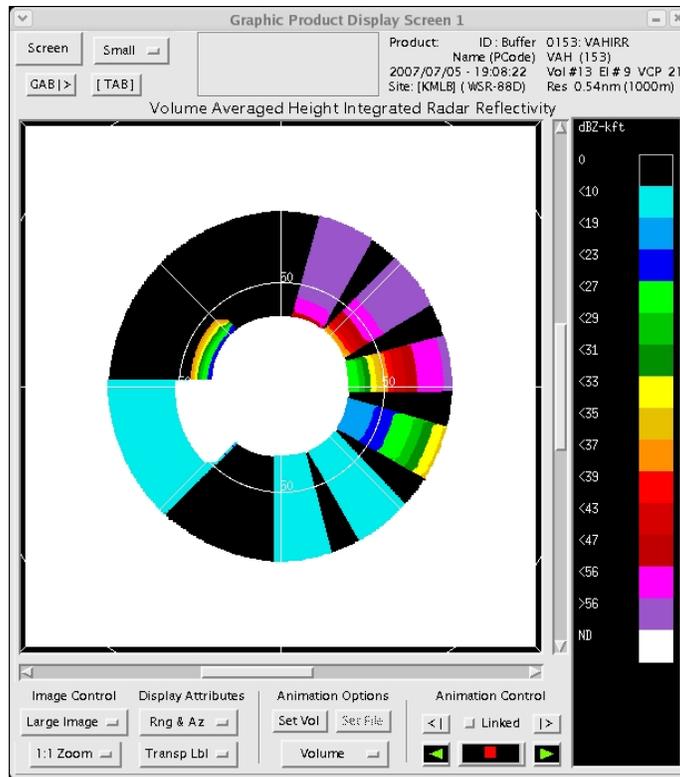


Figure 24. VAHIRR product (zoomed out) resulting from the Cone of Silence Height of 65.616 kft AGL Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

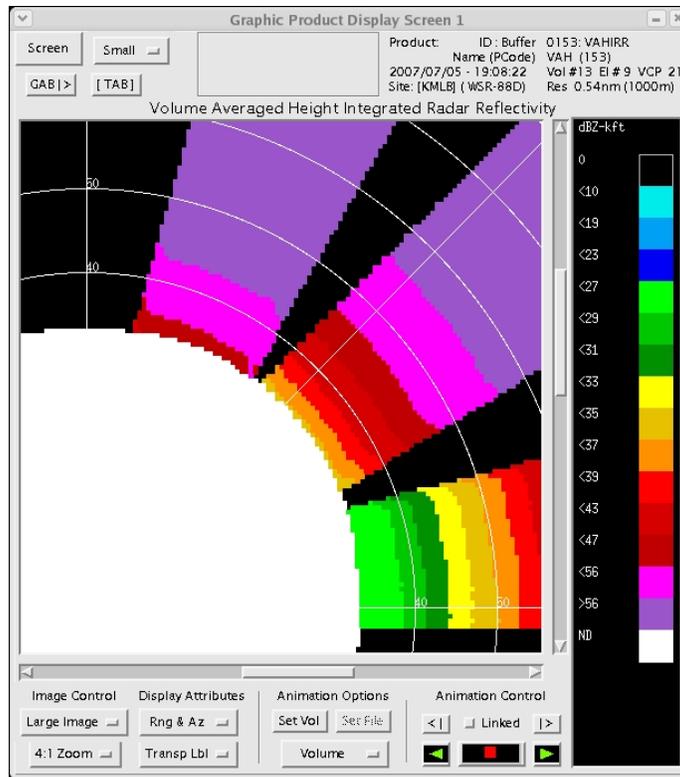


Figure 25. VAHIRR product (zoomed in) resulting from the Cone of Silence Height of 65.616 kft AGL Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

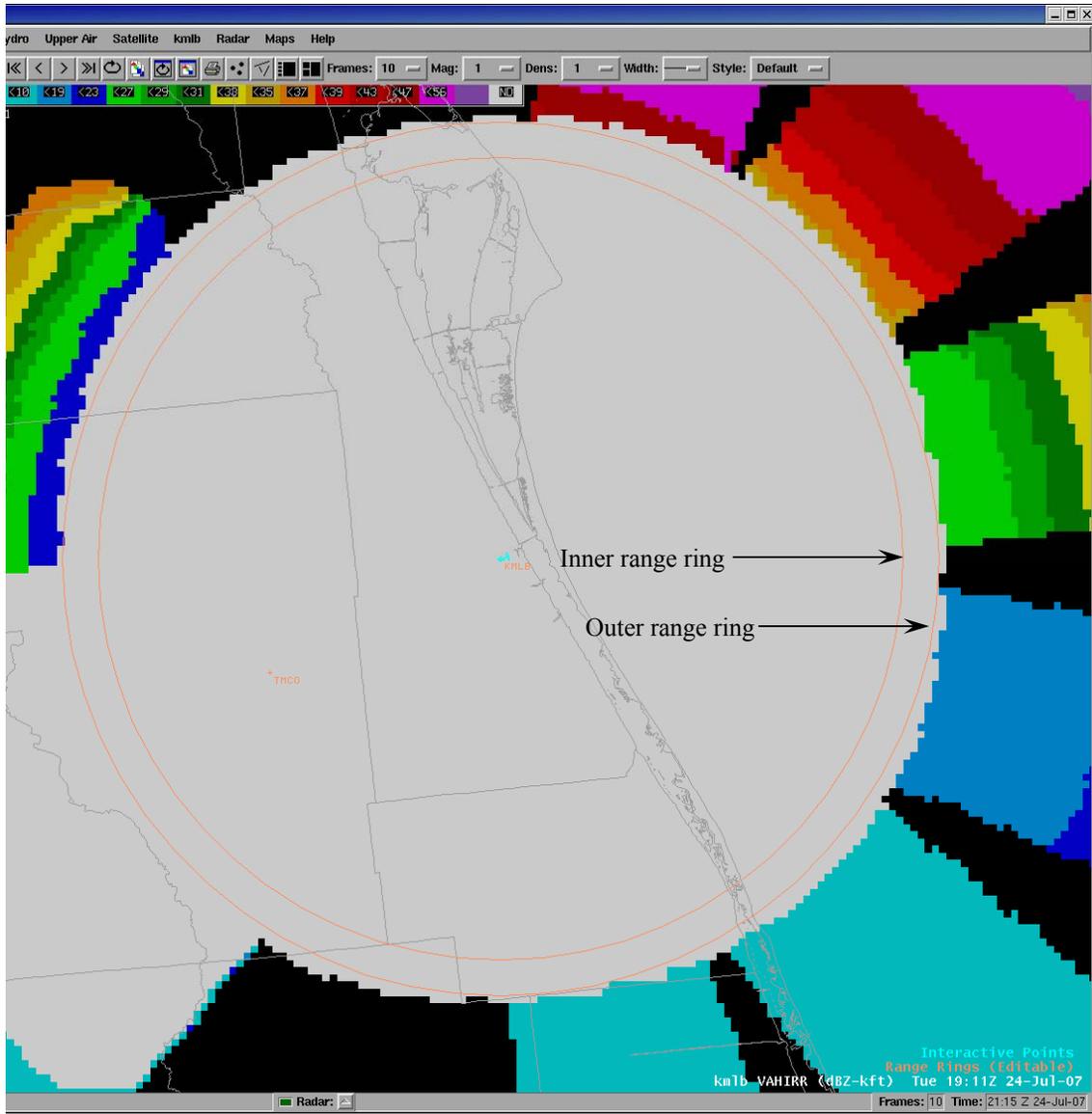


Figure 26. VAHIRR product displayed in AWIPS, resulting from the Cone of Silence Height of 65.616 kft AGL Test Case. The color scale for the VAHIRR values is in the upper-left portion of the figure. VAHIRR values that cannot be calculated are displayed in light grey. The inner range ring shows the calculated horizontal extent of the Cone Of Silence. The radius of the outer range ring is 5 km larger than that of the inner range ring.

5.7 Cone of Silence Height of 65.7 kft AGL Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1)

Requirements: 1, 2, 4, 5, 10

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the cone of silence height (line 1) to be “65.7”, **Save** and **Close** the file
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
`play_a2 -s BL_2007_07_05_19_08_22.bz2 -x 10 -n 1 <enter>`
 Note: This step is complete when the following message is received: “Specified maximum number of volumes reached”.
- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify message:
cone height 65.70 kft/20.00 km (agl)
 Note: When the cone of silence height is out of range, it is set to the default height of 65.616 kft (20km).
- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “153” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 (zoom Screen 1) to Figure 27.
- ___ 8) Compare Figure 27 to Figure 15. Since the Cone of Silence height is above the maximum, it has been set to the default of 20 km. The Cone of Silence is identical in the two figures since the Cone of Silence height is the same. In the figures, the areas within 5 km of the Cone of Silence are displayed in white.

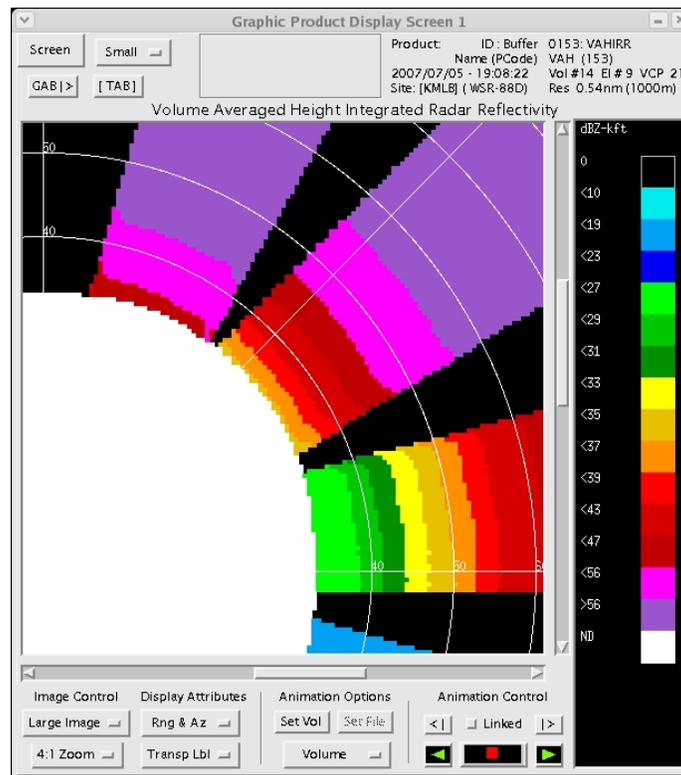
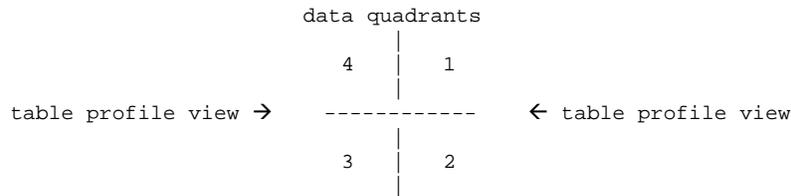


Figure 27. VAHIRR product resulting from the Cone of Silence Height of 65.7 kft AGL Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

6. Reflectivity Average for Multiple Tilts Test Procedure

The objective of this test procedure was to demonstrate that the product averages reflectivity equal to or greater than 0.0 dBZ from all tilts of a VCP vertically above a grid point. This test ensures the software does not stop calculating a vertical average when negative reflectivity is encountered. The test procedure also demonstrates varying cloud thicknesses in relation to the 0° Celsius height.



Bold underline represents the 0° Celsius height in the table.

elev	quadrant 4				quadrant 3				quadrant 2				quadrant 1			
9																
8																
7																
6																
5																
4																
3																
2																
1																

Figure 28. A representative profile of static reflectivity data in azimuth blocks of elevations of the volume scan (all reflectivity values are 2 dBZ).

Reflectivity Average for Multiple Tilts Test Case

VAHIRR Requirements/Condition Branches: (Requirements in Section 2.3 of Volume 1, Condition Branches in Section 8 of this volume)

Requirements: 1, 2, 4, 5, 6, 7, 10

Condition Branches: Beam spacing

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. The pre-test procedure is complete. This test was performed at the ENSCO Cocoa Beach facility.

Date: _____ Start Time: _____

On the test computer

- ___ 1) (Terminal Window #4) In an editor, open file `vahirr_parms.cfg` and modify the cone of silence (line 1) to be “35” and 0° C height (line 2) to be “10.5”, **Save** and **Close** the file.
- ___ 2) (Terminal Window #1) Ingest the baseline data file by typing:
`play_a2 -s tst6.1_2007_07_11_14_23_47.bz2 -x 10 -n 1 <enter>`
 Note: This step is complete when the following message is received: “Specified maximum number of volumes reached”.
- ___ 3) (Terminal Window #3) In an editor, open file `vahirr_prod.output` and verify messages:
cone-of-silence parameter - 35.000 kft
0C height parameter – 10.500 kft

- ___ 4) On the CODEview Graphics GUI, select **Screen 1** button, select **PCode** button, enter “153” in the box to the right of PCode, and select **Update List & Filter** button.
- ___ 5) On the CODEview Graphics GUI, select the current VAHIRR entry and select **Select Database Product** button.
- ___ 6) In the resulting window, select **OK (Select All)** button. The VAHIRR product is displayed in Graphic Product Display Screen 1.
- ___ 7) Compare the VAHIRR product displayed in Graphic Product Display Screen 1 against Figure 29. Eight cells are shown, in which there are elevation scans with negative reflectivity surrounded by elevation scans with non-negative reflectivity.
- ___ 8) On the CODEview Graphics GUI, select **Screen 2** button, enter the desired volume in the box to the right of **Vol**, select **PCode** button, enter “94” in the box to the right of **PCode**, and select **Update List & Filter** button.
- ___ 9) On the CODEview Graphics GUI, select the entry for elevation 1 and select **Select Database Product** button.
- ___ 10) In the resulting window, select **OK (Select All)** button. The desired Base Reflectivity Data Array Product is displayed in Graphic Product Display Screen 2.
- ___ 11) Repeat the previous two steps to view the Base Reflectivity products that make up the test procedure’s data set (compare to Figures 30 through 38).

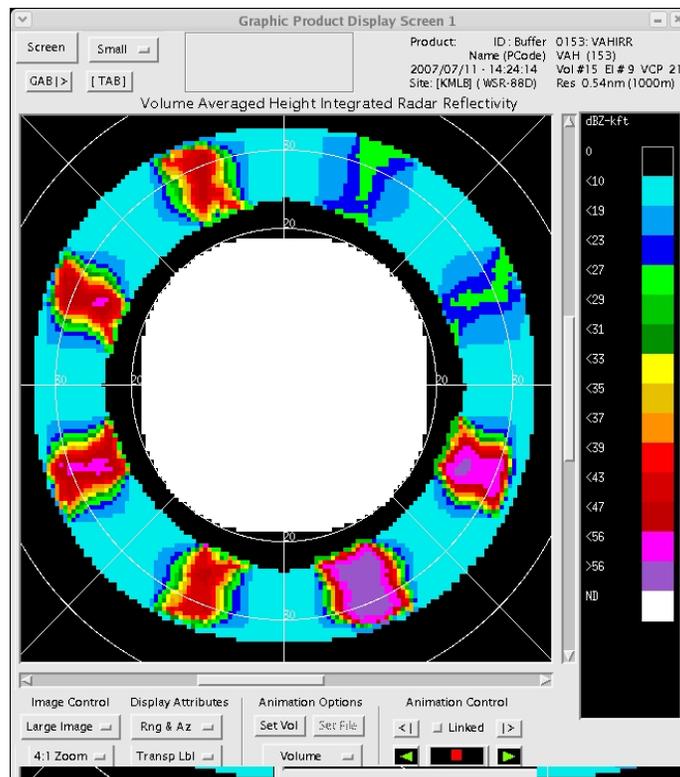


Figure 29. VAHIRR product resulting from the Reflectivity Average for Multiple Tilts Test Case. The color scale for the VAHIRR values is in the right-side of the figure. The VAHIRR values that cannot be calculated are displayed in white.

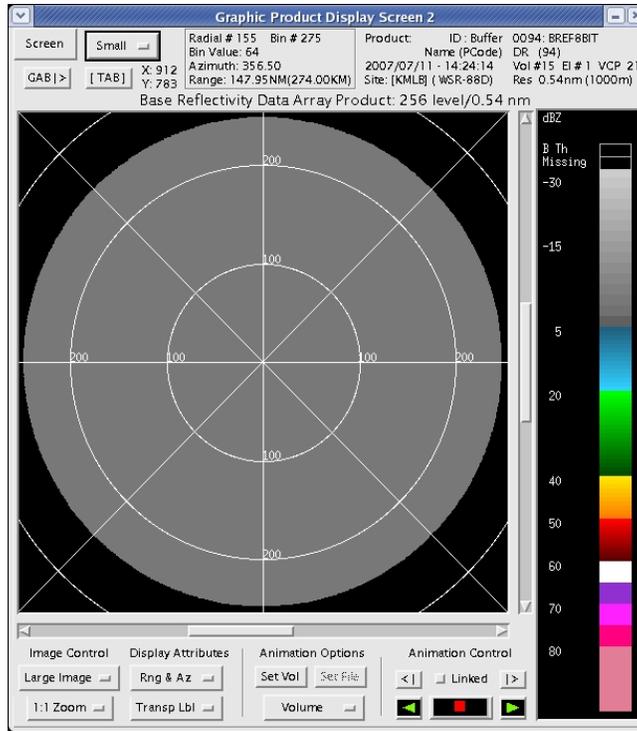


Figure 30. The 8-bit base reflectivity product for Elevation Scan #1 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

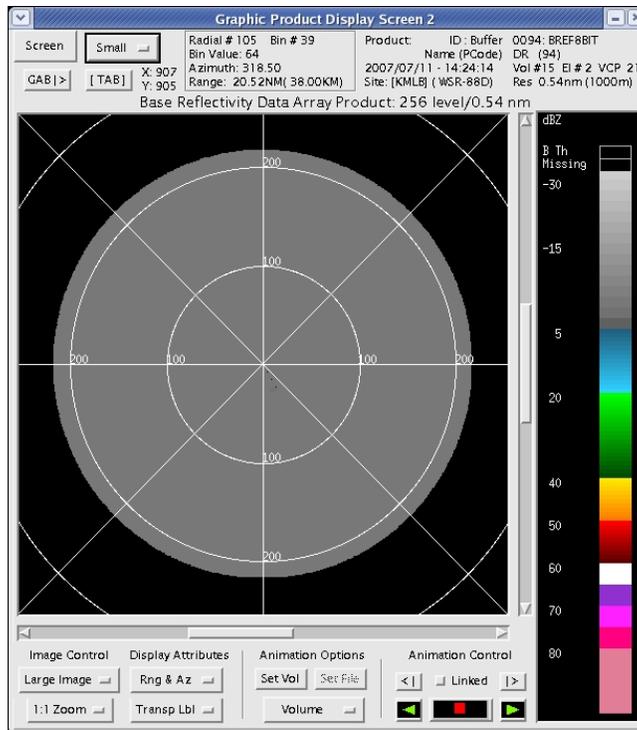


Figure 31. The 8-bit base reflectivity product for Elevation Scan #2 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

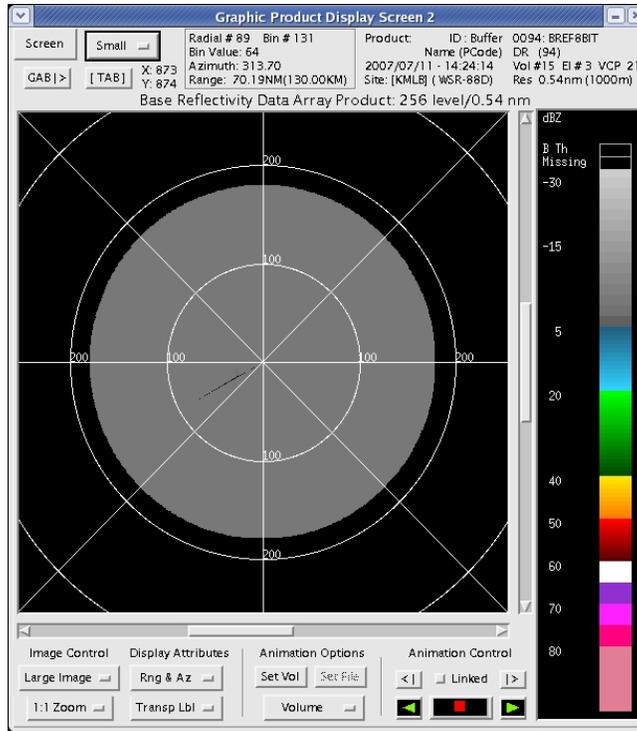


Figure 32. The 8-bit base reflectivity product for Elevation Scan #3 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

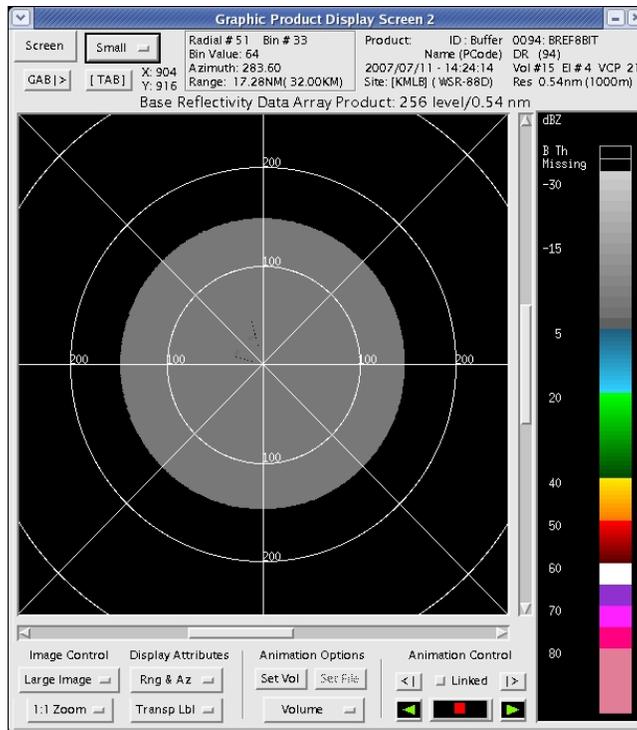


Figure 33. The 8-bit base reflectivity product for Elevation Scan #4 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

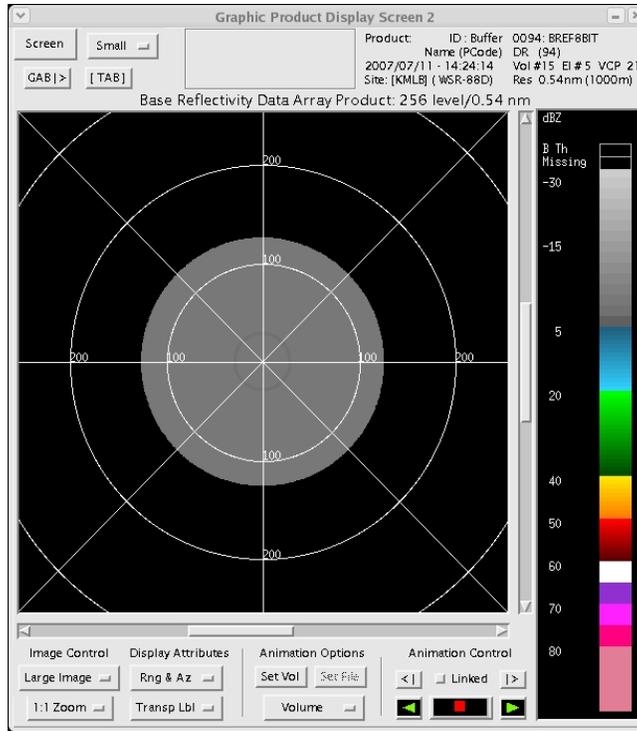


Figure 34. The 8-bit base reflectivity product for Elevation Scan #5 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

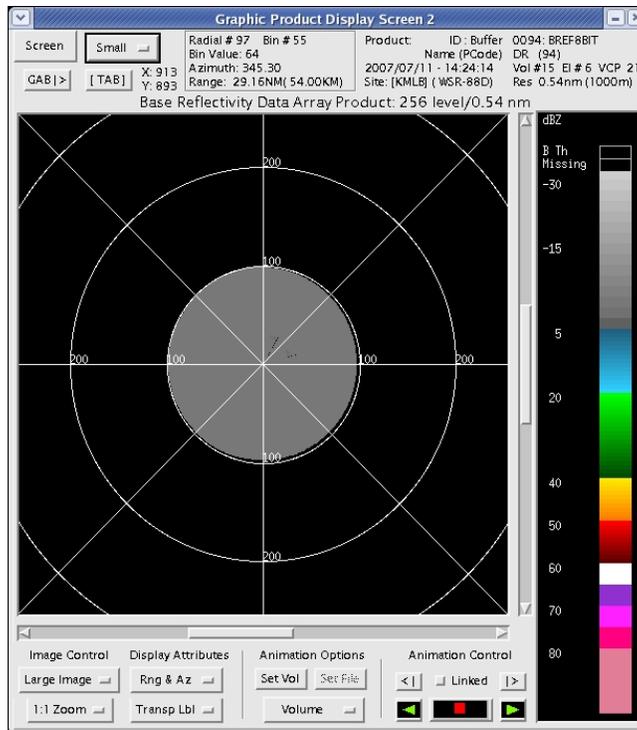


Figure 35. The 8-bit base reflectivity product for Elevation Scan #6 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

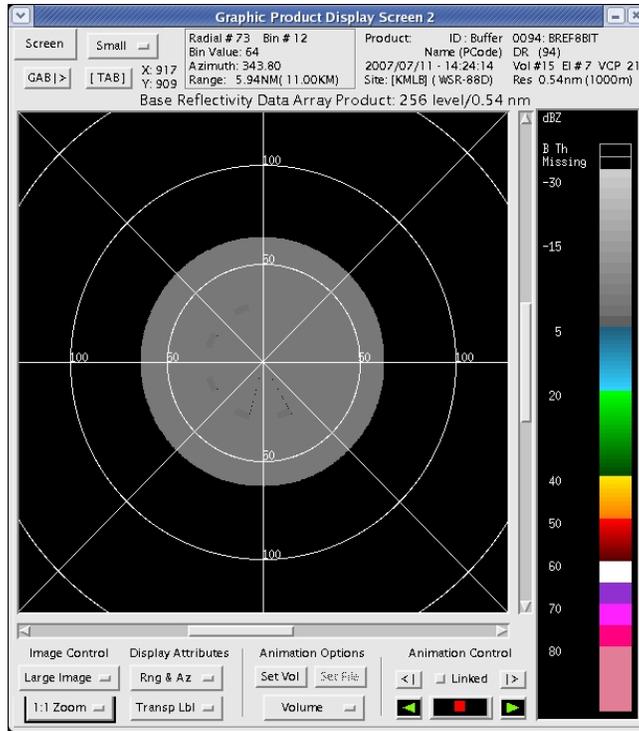


Figure 36. The 8-bit base reflectivity product for Elevation Scan #7 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

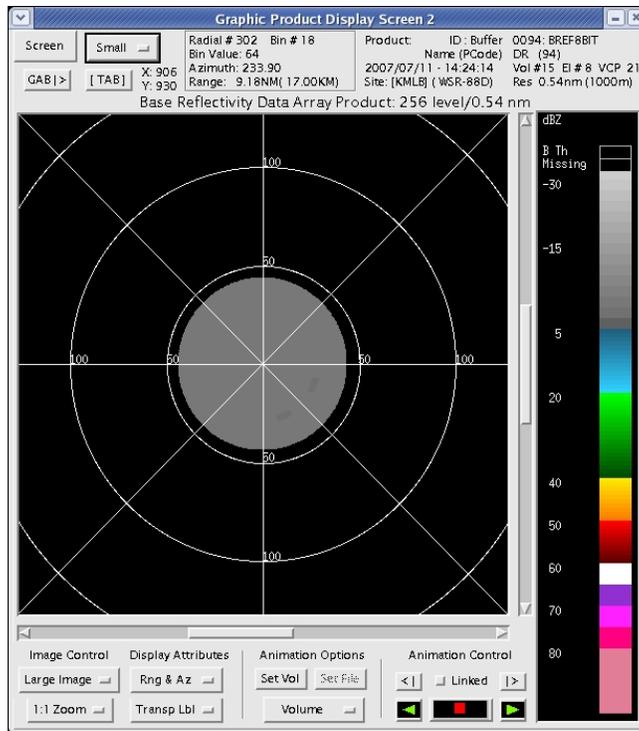


Figure 37. The 8-bit base reflectivity product for Elevation Scan #8 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

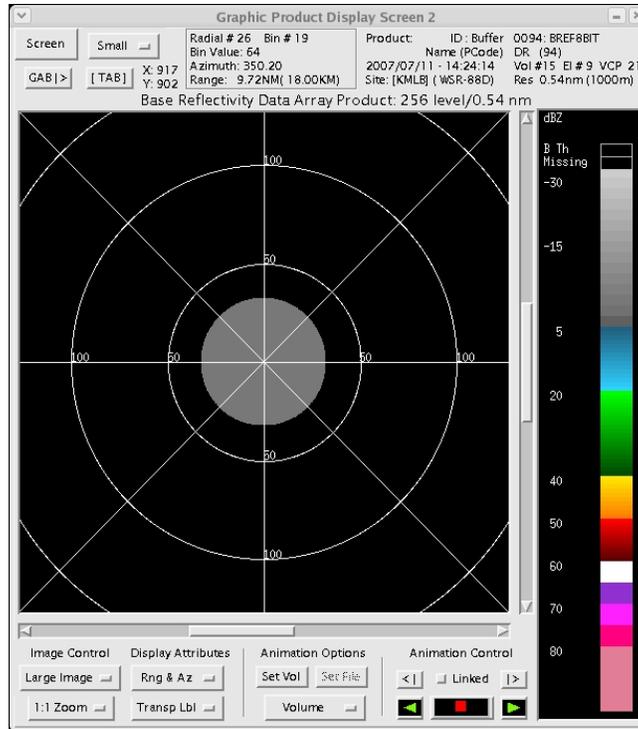


Figure 38. The 8-bit base reflectivity product for Elevation Scan #9 in the multiple tilts data set. The color scale for the reflectivity values is in the right-side of the figure.

7. ABFM Comparison Test Procedure

The VAHIRR algorithm is based on the work done during the ABFM II program. Several algorithms were tested by the ABFM II science team to determine the best radar product to identify environments conducive for natural or triggered lightning. The best predictor was the VOLINTG11X11_0 radar product, referred to as the ABFM VAHIRR product.

This test procedure compares the AMU VAHIRR product to the Airborne Field Mill II Project (ABFM) VAHIRR product. The AMU VAHIRR product, uses the Common Operations and Development Environment (CODE), which is an algorithm development environment for the Weather Surveillance Radar 1988 Doppler (WSR88D).

ABFM Comparison Test Case

VAHIRR Requirements/Condition Branches: None

Initialization/Assumptions: The system is powered up. All required software and data files are loaded on the hard drives. This test was performed in the AMU at the MOC.

Date: _____ Start Time: _____

On the test computer

- ___ 1) Using a web browser, navigate to the ABFM II website (<http://abfm.ksc.nasa.gov>). There is a list of case study days on the left side of the main page. Choose a case study day that does not have any major data-quality issues, such as missing NEXRAD data or aircraft instrumentation problems, as discussed in the Synthesis or Brief Notes section.
- ___ 2) After selecting a case study day, navigate to section 7 (CAPPIs) of the case study's main webpage. Select the applet labeled G1. Loop through all of the times in the applet. The volume scan time is the second

number in the graphic's label. For example, the label "NEXRAD 000611 182400 183000" indicates that the volume scan time is 1824 UTC on 11 June 2000. Continuing with this example, the next volume scan time is 1830 UTC. The volume scan time is when the radar begins collecting data for a new volume scan. For a particular volume scan, the start position of the aircraft is its position at the beginning of the volume scan. The end of the track is its position at the beginning of the next volume scan.

- ___ 3) While looping through the applet, make a note of the volume scan times in which the aircraft is going through relatively weak reflectivity gradients.
- ___ 4) Go back to the main webpage for the chosen case study day. Select the G1 link under the NEXRAD label, which is under the ASCII Data Files label. Open the webpage as a new window. To make the information easier to view, save the webpage as a text file. Delete the headers at the beginning of the file, then import the text file into a spreadsheet program, such as Excel. Only use the following columns of the file: Date, HHMMSS, POS_Lat, POS_Lon, and VOLINTG11X11_0.
- ___ 5) From the volume scan times selected in step 3, look up the VOLINTG11X11_0 values. For example, if a particular volume scan time is 204510 (10 seconds after 2045 UTC) and the next volume scan time is 205100, then the VOLINTG11X11_0 values of interest in the text file correspond to the HHMMSS times between 204520 and 205050. From the volume scan times already selected in step 3, select HHMMSS times in which the VOLINTG11X11_0 values are less than 17 dBZ-km (56 dBZ-kft). This is because the highest color table value in the VAHIRR product corresponds to 56 dBZ-kft or greater.
- ___ 6) After selecting the HHMMSS times, navigate to the National Climatic Data Center's (NCDC) website to order Archive II WSR-88D data (<http://www.ncdc.noaa.gov/nexradinv>). After ordering the data, NCDC will send an email when the data is ready for download. Store the Archive II radar data files on the hard drive. As a default, Windows XP will save these files with a .tgz extension, even though they are not tar-zipped files. They are gzipped files (.gz extension).
- ___ 7) Upload the Archive II radar data files to the ORPG-clone. The files should be placed in the ORPG data directory (e.g. \$HOME/data/ABFM/June13_2000). Rename the files so that they have a .Z or .gz extension. Decompress the files with the gunzip utility. The unzipped files should not have a file extension. Compress the files with the bzip2 utility.
- ___ 8) Log into the ORPG-clone as the ORPG user. In a terminal window, enter:
mrpg -r -v startup
- ___ 9) Set the freezing level in the HCI application to 5 km, or 16.4 kft, since this is the value used in the ABFM II project. In the \$HOME/cfg/vahirr_parms.cfg file, set the cone of silence height to 0.0 (first line).
- ___ 10) Read the Archive II radar data files on the ORPG-clone with the play_a2 utility. Here is an example:
play_a2 -d /home/codev8/data/ABFM/June13_2000 -x 5. This utility will read all Archive II radar data files in chronological order five times quicker than in real time.
- ___ 11) After the play_a2 utility finishes, start the cvg utility to verify that the radar products, including VAHIRR, were created successfully for each volume scan.
- ___ 12) Open a new terminal window. Extract the VAHIRR radar product for each volume scan from the product database. First, get the message number of each VAHIRR product in the database by entering: **cvt slb 153**
- ___ 13) Next, get the volume scan time for each product with the cvt msg utility. Note that the volume scan time will be output in local time, so add four hours to convert to UTC during EDT and five hours during EST. For example, assume that there are two VAHIRR products from two volume scans in the product database, and their message numbers are 344 and 525. To get the volume scan time for message 344, enter: **cvt msg 344**. To get the volume scan time for message 525, enter: **cvt msg 525**. Assume that the volume scan times for messages 344 and 525 are 21:15:00 and 21:20:05 on June 13, 2000. Create a new subdirectory in the \$HOME directory, e.g. \$HOME/extracted. To extract message 344, enter: **cvt msg 344 extract -nohdr -out extracted/20000613_2115**, where extracted is the name of the subdirectory that was just created. To extract message 525, enter: **cvt msg 525 extract -nohdr -out extracted/20000613_2120**

- ___ 14) Copy the files from the `$HOME/extracted` directory to the AMU AWIPS server. The filenames of the extracted radar products must be in the correct format to be read by AWIPS: `yyyymmdd_hhmm`, where `yyyy` is the four-digit year, `mm` is the two-digit month, `dd` is the two-digit day, `hh` is the two-digit hour, and `mm` is the two-digit minute. If the directions in step 13 were followed, then the filenames should already be in the correct format. Verify that the AMU AWIPS client is mounted to the AMU AWIPS server, and then verify that the ORPG-clone is mounted to the AMU AWIPS server. In the AMU Standard Operating Procedure titled “Creating VAHIRR radar products with AMU’s ORPG-clone”, part II explains how to verify that the AWIPS client is mounted to the AMU AWIPS server, while part III explains how to verify that the ORPG-clone is mounted to the AMU AWIPS server. Copy the extracted files to the `/data/fixa/radar/kmlb/VAHIRR/layer0/res1/level16` directory from the `$HOME/extracted` directory. Afterwards, verify that the radar files can be viewed in the AWIPS D2D application with the VAHIRR product button in the kmlb radar menu.
- ___ 15) Go back to the G1 text file that was saved in step 4. For at least two separate volume scans, make a note of five different `VOLINTG11X11_0` values from the text file. From the lat/lon coordinates in the text file, estimate the VAHIRR values on the radar product in AWIPS, using the lat/lon readout and the VAHIRR color table. All 10 VAHIRR values should be within two data levels of the `VOLINTG11X11_0` values. Some differences are expected due to slight errors in ABFM aircraft position calculations and differences in software implementations. A comparison cannot be performed for locations where the VAHIRR output value is ND (no data), which indicates that the highest elevation scan contains non-negative reflectivity or that the lowest elevation scan is above the freezing level. [Here is a hypothetical example:](#)
- ___ 16) Volume scan: 20000613_2115

HHMMSS	Lat.	Long.	VOLING11X11_0	VAHIRR
211530	28.10	80.70	50	47 to <56
211540	28.12	80.72	47	47 to <56
211550	28.14	80.74	47	47 to <56
221600	28.16	80.76	44	43 to <47
221610	28.18	80.78	40	39 to <43

Volume scan: 20000613_2120

HHMMSS	Lat.	Long.	VOLING11X11_0	VAHIRR
212230	28.20	80.80	23	23 to <27
212240	28.22	80.82	25	23 to <27
212250	28.24	80.84	28	23 to <27
222600	28.26	80.86	29	27 to <29
222610	28.28	80.88	26	23 to <27

Pass _ Fail _

8. VAHIRR Conditional Branches

The following table shows the conditional branches tested in the VAHIRR Factory Acceptance Test.

Variable	Units	Value1	Value2	Value3	Value4
Reflectivity	dBZ	no reflectivity	< 0	= 0	> 0
Altitude of cloud base	km or kft	< 0°C height	= 0°C height	> 0°C height	
Altitude of cloud top	km or kft	< highest elevation scan	≥ highest elevation scan		< 0°C height
Location of box wrt cone of silence	latitude, longitude	outside cone of silence	partially in cone of silence		
Beam spacing	km	Range 20 n mi	Range 100 n mi		

Beam spacing discussion – Given adjacent beams centered on heights h1 and h2 above a particular surface point:

A. Given a cloud top appearing in the lower beam (h1) but not the upper (h2), the top height should be computed as $h1 + 0.5 * (h2 - h1)$.

B. Given a cloud base appearing in the upper beam (h2) but not the lower (h1), the base height should be computed as $h2 - 0.5 * (h2 - h1)$.

C. For the purposes of A and B, reflectivity < 0 dBZ is the same as no reflectivity.

